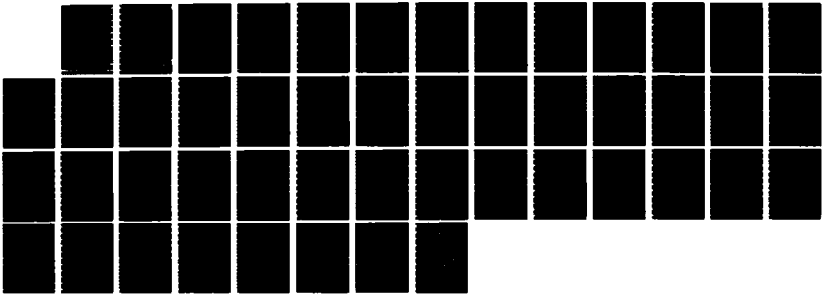
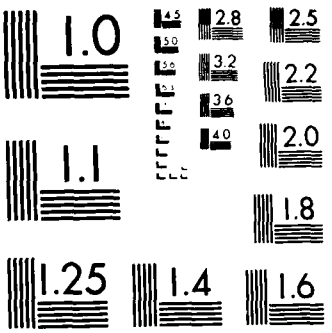
AD-A175 869 AN INTEGRATED THEORY OF DISCOURSE ANALYSIS(U) 1/1
MASSACHUSETTS UNIV AMHERST DEPT OF COMPUTER AND
INFORMATION SCIENCE J PUSTEJOVSKY MAR 86 CPTM-11
UNCLASSIFIED N00014-85-K-0017 F/G 9/2 NL





The Counselor Project

Department of Computer and Information Science
University of Massachusetts
Amherst, Mass. 01003

An Integrated Theory of Discourse Analysis

James Pustejovsky
March, 1986
CPTM #11

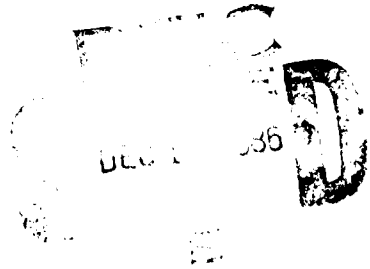
This series of internal memos describes research in artificial intelligence conducted under DARPA Contract N00014-85-K-0017

2

An Integrated Theory of Discourse Analysis

James Pustejovsky
March, 1986
CPTM #11

This research was supported by DARPA grant N00014-85-K-0017.



An Integrated Theory of Discourse Analysis

James Pustejovsky
Department of Computer and Information Sciences
University of Massachusetts at Amherst, 01003
CSNET Address: JAMESP@UMASS

Abstract

In this paper I would like to explore some difficult questions related to topics in discourse analysis and offer a partial solution to some of them. In particular, I will address the issue of *levels* in discourse analysis and how the various approaches taken within the field can be classified according to a leveled model. I then want to consider an approach I have been pursuing for representing the semantics of discourse, and consider how it fits in to the proposed model for discourse analysis. Finally, I describe the implementation of a system which models the behavior of the proposed model.

1. Approaches to Discourse Analysis

There has been a great deal of renewed interest generated lately in the area of discourse analysis, motivated in part by the influence of researchers in Artificial Intelligence (AI), attempting to design "natural language conversation systems." As with many branches of AI, it at times appears as though we are reinventing the wheel, failing to take stock of past work done in related disciplines such as linguistics, philosophy, and psychology. However, much of the work has added new and complex dimensions to the study of discourse analysis (including speech act theory). I am thinking in particular of the works of Allen, Cohen and Perrault on the role of planning in speech acts; Wilks and Bien and the *Point of View* principle; and the recent work done on conversational moves and clue words,

by Webber, Grosz, Sidner, Reichman, and others. The immediate uniformity between these approaches is that they are concerned with process oriented models of discourse understanding rather than claiming to being competence models.

1.1 Setting the Stage

In this section I will review what I think is crucial to discourse analysis and semantics. In the next section I will survey the work done in the field and classify this research according to three general approaches. Then the limitations of each of these approaches will be discussed in some detail. In the following section I will outline an integrated theory of discourse semantics, building on the research discussed in the previous sections. Finally, in Section 4.0, I discuss an implementation of a program, CICERO, which embodies much of the theory presented here.

In what follows I will attempt to classify the different factors influencing the "understanding" of a discourse, and how these have been analyzed and dealt with in the field. I will assume a traditional classification of the communicative content of an utterance, U:[1]

(1)

1. Truth-conditional semantics for U.
2. Entailments from U.
3. Presuppositions from U.
4. Conventional implicatures from U.
5. Conversational implicatures from U.

[1] I will follow Grice's classification as being essentially correct. See Grice (1971, 1968, 1969) for further discussion.

6. Felicity conditions associated with U.

The distinction here between entailment and presupposition is, of course the familiar one (Strawson (1952)). "Entailment" we will identify with "logical consequence" and state informally as:

(2) α semantically entails β iff every situation that makes α true makes β true.

Presupposition will be defined as follows:[2]

(3) α presupposes β iff:

i. if α is true, then β is true;

ii. if α is false, then β is true.

Some classic examples will illustrate this distinction. Consider the sentences below in (4) and (5).

(4) a. All of John's children are asleep.

b. John has children.

(5) a. John has stopped beating his wife.

b. John was beating his wife.

Sentence (4a) is said to "semantically presuppose" (4b), but not entail it. For if sentence (4b) is false then we say that (4a) lacks a truth value.

---

[2] Strawson's view of presupposition, of course, states that this relation holds of "statements", whereas some take this to be a relation between sentences.

With the sentences in (5) we see what is called "pragmatic presupposition". By the use of the aspectual modifying verb 'stop' we are eliciting the presupposition in (5b). As with the pair in (4), if (5b) is false, then there is something strange about (5a) (and in Strawson's theory, this translates to the lack of a truth-value for this statement).

There are two other types of pragmatic presuppostions that should be mentioned here. One refers to certain conditions that must be met for a speech act to be "felicitous" and appropriate in a specified situation. For example, (6b) is a reasonable assumption or presupposition for (6a) (The example is taken from Fillmore (1971)).

(6) a. John accused Harry of writing the letter.

b. There was something blameworthy about writing the letter.

Finally, there is the influence of the background knowledge (shared information) when making an utterance in a context, that can be thought of as presuppositional. Consider the sentences in (7).

(7) a. It wasn't Mary that John married.

b. John didn't marry MARY (focused).

c. John married someone, (and in fact someone else).

The assumed knowledge between the speaker and the hearer in this case, (7a) or (7b), is the proposition in (7c). The presupposition is accomplished by different means in each sentence, however. (7a) seems to have (7c) as a presupposition because it is in a cleft construction. (7b) has the presupposition in (7c) because it carries focus on the object

position.[3]

Having reviewed the types of presuppositions, we should note what the role of conventional implicatures is in discourse analysis. These are non-truth conditional inferences that are associated (or "attached") to certain lexical items. For example, the words 'but' and conventional implicature that there is a contrast of some sort between the conjoined elements. When we examine the work of Reichman and other structural analysts in the next section, the interpretation of clue words will determine just such inferences for the discourse.

Central to Grice's theory of language use is the notion of the conversational implicature. The major "principle" governing a person's behavior in a discourse is formulated as follows (Grice (1975)).

(8) Cooperative Principle: Make your conversational contribution such as is required, at the stage at which it occurs, by the accepted purpose or direction of the talk-exchange in which you are engaged.

This subsumes the maxims of quantity, quality, relation, and manner. We will not discuss these in any detail in this paper (but see Bach and Harnish (1982) for a clear exposition of their role in discourse).

Finally, consider the import of felicity conditions in the understanding of an utterance in discourse. These are the conditions that are required for "nondefective" communication. Felicity conditions are to be distinguished from the "success conditions", which are those

[3] The effect of focus on presuppositions has long been known. Behagel (1934) mentions this in the context of its relation to theme-rheme structure of a sentence and the discourse implicatures accompanying it. This was also noted by the Prague linguists, cf. Hajicova (1981). Recently Rooth (1985) has examined the issues surrounding focus and presupposition as well.

conditions that are necessary and sufficient for the performance of an act. In our discussion, we will assume that such conditions are necessary, but will have little to say about that here.[4]

Along with the these semantic aspects of an utterance, we must include the deeper coherence relations in a discourse, such as causal, temporal, spatial, and definitional considerations. We will have more to say about these later.

It is difficult to address one of the areas above without getting involved in at least one other. Therefore no clearly delineated classification is possible for "who works on which topic" and just what is meant by "semantics." Nevertheless, I would like to compare the work done on these topics by establishing what feeding relationship exists between them.

Let us begin by identifying what appear to be the three major approaches to discourse analysis:

(9) a. Structural Analysis

b. Goal Recognition

c. Model Theory

We turn immediately to the first approach in the next section.

1.1 Structural Analysis

[4] But see Austin (1962) and Searle (1969) for the best discussion of this issue.

The major concerns of those working in this paradigm are to identify structural elements such as *topic*, *focus*, *discourse moves*, and *context spaces*. This approach is primarily concerned with how the structure of a discourse influences the interpretation as well as the linguistic realizations of a text. Chief proponents of this view are Grosz, Webber, Reichman, and Sidner, as well as Mann and Thompson

Early work by Webber (1979) and Grosz (1978, 1981) was aimed at identifying the contexts within which discourse anaphora was licensed. The of *focus* and *topic* was adopted to delimit the space within which anaphoric binding is possible. That is, only if something is labeled with such a discourse marker can certain pronominal references be licensed.

As Reichman (1984) puts it, the purpose of discourse analysis is to identify "a conversation's deep structure in terms of the structural relations between the discourse elements."[5] In this view discourse structure is defined by the conversational moves (CM) taken by the participants in the discourse. Each move takes the discourse into a new stage; that is, each move has associated effects. Also central to this model for discourse analysis is the notion of *context space*, which is an "abstract structure" taking into account the following components:

(10)

1. The propositional representation of the discourse utterance.
2. The conversational move (CM).
3. The Preconditions for the move
4. Links to previous disourse spaces.
5. Focus level assignments for various elements in the context space.

---

[5] Cf. Reichman (1984) for a full discussion.

According to Reichman's view, all discourse utterances obey certain rules, regardless of the type of discourse. A few of the more important ones are given below.

(11)

1. Conversation is a series of moves linked by functional relations.
2. Utterances in a single context space serve the same move.
3. A move has preconditions and effects associated with the underlying discourse structure.
4. While in a subspace, the containing context space retains control.
5. Inter-sentential anaphoric binding is possible only with high focus items.

Central to this model of discourse analysis is the belief that conversational moves (moves) are recoverable from the specific linguistic structure of the text. Thus, we have a taxonomy of possible moves and the clue words most frequently associated with them:

(12)

MOVE	CLUE WORD
1. support	Because; Like
2. restatement and/or conclusion of point supported	So
3. Interruption	By the way
4. Return to interrupted space	Anyway
5. Indirect challenge	Yes, but
6. Direct challenge	(No) but
7. Subargument concession	All right
8. Prior logical abstraction	But look
9. Further development	Now

The "deep structure" of a discourse consists of a sequence of the above moves, through which a conventional interpretation (the understanding of the discourse) is accomplished. This essentially involves recovering the *mutual knowledge* between the participants in the discourse.

Also very conscious of the role that discourse segments and clue words play in the proper analysis of discourse is the recent work by Grosz and Sidner (1986). They propose a model of discourse structure with three interacting components:

1. A linguistic structure: the utterance itself.
2. An intentional structure; and
3. An attentional state: an abstraction of the focus of attention of the discourse participants.

Central to their model is the notion of a Discourse Purpose (DP), which is the "intention that underlies engaging in a discourse." There is one discourse segment purpose for each discourse segment. Furthermore, the process of manipulating focus spaces, referred to as *focusing*, combines with the DP to control the emerging discourse.[6]

---

[6] Grosz and Sidner's (1986) paper became available to me much too late to critique and review thoroughly, so I undoubtably do it an injustice here. Cf. Pustejovsky (in preparation) for a closer analysis of this work and the relevance to our model presented here.

1.2 Goal Recognition

A very different approach to discourse analysis is that which I will call *Goal Recognition*. This differs significantly from the structural analysis school in one important respect: what is being recovered from an utterance and what is being represented as the understanding of the discourse (or text) is something much deeper than the structural form of the text. Within this approach we can single out two major schools of thought: those concerned with narrative form, coherence, and story understanding (Schank, Abelson, Hobbs, and Wilensky); and those concerned with the recognition of speech acts and intentions (Cohen, Allen, and Perrault).

For Schank and Abelson (1977), and much of the Yale school, understanding a text is a problem of inference generation and control. That is, a reader attempts to find the implicit connections between the sentences in the text. As a solution to the infinite search space problem of inferences, they proposed that there are script-like knowledge structures which we can access in order to understand stories. Thus we recover these prototypical event-sequences, the scripts, and form a coherent understanding of the text.

Wilensky (1982) points out a number of problems with this approach, chief among them the fact that not all stories or texts can be characterized as stereotypical sequences of events. He proposes a theory of text coherence that incorporates the goals and plans that actors in a text may have. Thus, we try to recognize what the intention of the actor is and piece together the text on the basis of this goal.

Whereas Wilensky is concerned more with the underlying intentions and goals of the agents in a text, Hobbs (1978, 1982) attempts a general classification of coherence relations that may exist in a text. The two that he examines in detail (Hobbs 1982) are *elaboration* and *occasion*. These relations are formal constraints on an inference mechanism which

constructs a tree-like structure for a discourse containing all the asserted and presupposed propositions (cf. Hobbs (1980)).

Lehnert (1978, 1982) is also critical of the purely script-based and story grammar approach to understanding as being too top-down oriented. She proposes a system of text analysis and memory organization which has the features of bottom-up processing as well.

In this theory the underlying notion of coherence is based on *affect states* and *plot units*. Affect states are a set of primitive predicates over states and events, with values *positive*, *negative*, or *neutral*. That is, an event is positive, etc. with respect to an object. These states are bound to objects.

In addition to these primitive predicates are links between event/state pairs that describe causal coherence relations. These are: motivation, activation, termination, and equivalence. From these notions Lehnert then defines the notion of plot unit: a *plot unit* is a directed labeled link from one affect state value to another. The underlying coherence of a narrative, then, is captured in terms of these units.

It is important to note that for these approaches, the inference processes are spawned as a result of the knowledge structures associated with propositions (and the plans they fall into) rather than linguistic or surface structural clues.[7]

Alterman (1985) proposes an interesting theory of text coherence based on the notion of *event concept coherence*. This property is part of the dictionary entry for an event/state description, and provides a way to group text into structured bundles, based on their relative coherence. Alterman makes three claims for this theory: (1) text is composed of structured chunks of conceptual event/state descriptions; (2) events can be bundled together

[7] This is not completely true, of course. Some researchers in this school make use of clue words just as Reichman and Polanyi and Scha.

without stating their complete causal connections; (3) the initial grouping and structuring of text can be done with simple augmentation of case relationships by inter-event relations.

The concept coherence relations assumed by Alterman are characterized as follows:

(13) a. Taxonomic–class/subclass

b. Partonomic

i. sequence/subsequence

ii. coordinate

c. Temporal

i. before

ii. after

Thus in an example such as (13), it is the relative proximity of the concepts *chop* and *drop* via the concept *hold* that establishes the coherence between the two sentences.

(13) a. The peasant was chopping a tree in the woods.

b. He dropped his axe...

A.pp Another approach that addresses questions of goal recognition is taken by Cohen, Allen, and Perrault. [8] These researchers have as their primary concern the recognition and modeling of the speaker's plans in a dialogue. According to this view, speakers' intentions can be thought of as plans, and speech acts are no different from any other actions. Hence, they can be planned and recognized with algorithms and heuristics already employed in AI for planning systems (e.g. STRIPS).

---

[8] The work of Grosz (1978) deals with tracking a dialogue topic in a task-oriented domain. She employed plan-tracking heuristics to this end, but did not embed speech acts into a general planning environment.

Following Cohen and Perrault (1979), this approach treats actions as operators defined in terms of *preconditions* (applicability conditions), *effects*, and *bodies*, which explicate how to achieve the effects. These are evaluated relative to the speaker's models of their listeners. Thus discourse processing in this view has nothing to do with the structure of the discourse per se but rather with the intentions of the speakers.[9]

The model that a speaker has of his listeners involves representing the beliefs and goals of those people. Belief is interpreted for Cohen and Perrault as a modal operator, A-BELIEVE, taking propositions as its argument. This formal treatment (cf. Hintikka (1969)) allows for infinite embeddings of belief contexts, with the advantages and problems of such an approach.[10]

Recently Litman and Allen (1984) have extended the planning paradigm to allow plans about the planning process itself. This allows for tracking clarification subdialogues while still keeping track of the plans associated with the speech act being performed.

Finally, another important approach to belief (and goal) recognition is that taken by Wilks and Bien (1983). This "least-effort"

approach to language understanding and belief representation is to be contrasted with that just mentioned, such as Allen and Perrault (1980). Wilks and Bien argue that deep nestings of beliefs could not possibly be efficient from a psychological or computational perspective. They propose as an alternative a theory of belief *percolation*, whereby temporary frames (pseudo-texts) indicating belief states can be pushed down into another such frame, if

---

[9] Recently Litman and Allen (1984) have proposed a model of plan recognition that does incorporate some of the strategies found in the structural analysis school. We will return to this theory below.

[10] For discussion of this topic, cf. Cohen and Perrault (1979).

necessary the understanding of a discourse.

1.3 Model Theory

Recently there has been much work done on discourse within formal approaches to linguistics and semantics. I am thinking in particular of the Discourse Representation Theories of Kamp (1981) and Heim (1982) and the recent work on Situation Semantics by Barwise and Perry (1983). These approaches take (at least in spirit) as their point of departure the formal framework proposed by Montague(1974) and Kaplan's work on indexicals and demonstratives (Kaplan 1977). There isn't room here to examine these works in detail, but I will review the major points of their theories.

Kamp's (1981) main concern is the correct interpretation and representation of discourse referents. Essentially, Kamp argues that deictic and anaphoric occurrences of pronouns are identical, and that identifying their antecedents involves selection from specified sets of previously available entities. Associated with an utterance is a discourse representation structure (DRS) containing the appropriate quantification over the entities in the proposition, as well as the propositional content. To illustrate, consider the DRS for (14a), shown in (15):

(14) a. Pedro owns a donkey.
b. He beats it.

(15)

u	v
.	.
Pedro owns a donkey	
u = Pedro	
u owns a donkey	
donkey(v)	
u owns v	

Now, the novel aspect of Kamp's proposal comes with the DRS for (14b). Because there

are no possible referents within (14b) for the two pronouns, it does not license a separate DRS but must rather be embedded within (or bound by) another, satisfying structure; in this case, (15). Hence we have the DRS for the discourse pair, shown in (16).

(16)

u	v
.	.
Pedro owns a doneky	
u = Pedro	
u owns a donkey	
donkey(v)	
u owns v	
He beats it	
u beats it	
u beats v	

The proper linking is now possible between the pronominals and their antecedents, since their is a common scope delimiter, viz. the DRS, which contains both binder and variable.

Heim's (1982) approach is similar to Kamp's in many respects, but her concerns is how to represent the presuppositions carried by utterances. Crucial to this theory is the notion of a *file*, a record on which descriptions of entities can be kept, and which is evaluated with respect to rules of familiarity and *file-change*.

According to Heim, every sentence has "file change potential. That is, every utterance has the potential to change the context set of the utterances following it. The common ground, in Stalnaker's (1979) terms, between the speaker and the hearer, is the set of presuppositions common to both. This is what is contained in the file of a context in Heim's theory. Another view that should be mentioned here is Lauri Carlson's game theory of discourse (Carlson (1983)). Space does not permit us to examine it here. However, we do discuss some of his ideas in Section 3.0.

Barwise and Perry (1983) provide the groundwork for a theory of situations and attitudes that allows for partial models rather than being tied to the exhaustive models of Montague semantics. I will have nothing further to say here about this approach.

2. Shortcomings of the Current Approaches to discourse analysis

It is clear from our discussion above that what counts as a representation of the discourse or as the "understanding" of the text differs wildly. In this section I would like to explore how these different representations interact and propose a model for discourse analysis incorporating these component parts.

2.1 Conversational Moves versus Coherence

Let us begin by examining the logical distinction between possible conversational moves in a discourse and possible types of coherence that tie a text together. Reichman and others, following Grice (1971), classify utterances according to the roles they play in the discourse;, e.g. supporting, elaborating, interrupting, etc. Others working in goal recognition have classified the types of coherence relations that exist between sentences in a text or discourse. These include causation, temporal ordering, but also notions such as elaboration and occasion. The problem here is that what some are calling *moves* in a discourse others term *coherence relations*.

Hobbs (1982), for example, describes the two coherence relations, *elaboration* and *occasion*. In the dialogue shown in (17), (b) is said to elaborate (a).

(17) a. John can open Bill's safe.

b. He knows the combination.

Similarly (18) is said to be an instance of an elaboration.

(18) a. Go down Washington St.

b. Just follow Washington St three blocks to Adams St.

Although the (b) examples above clearly elaborate the (a) sentences, there is much more that can be said about the coherence relations between them than this. The notion of

elaboration Hobbs is using here is *structural* coherence and is not significantly different from a conversational move for the structural analysts. In this sense I agree that both (17) and (18) are structural elaborations.

A deeper description, however, of the connectedness between the two sentences in (17) would involve something like a because-of relation; that is, the real coherence link here is *enablement* and not elaboration. The connectedness between (18a) and (18b), on the other hand, is one of identity. Although structurally an elaboration, (18b) reflects a changed performative strategy by the speaker, due to his/her model of the hearer's beliefs.

The other coherence relation Hobbs mentions is *occasion*, which can be defined simply as follows: A occasions B if A creates a state so that B can occur. An example of this is a text involving direction giving:

(19) a. Turn left.

b. Go to the corner.

By performing the action denoted in (19a) a change of location is effected that allows the action in (19b) to occur. The structural relationship between (a) and (b) is simply a continuation or further development, and I agree with Hobbs that the coherence link here is one of occasioning.

While Hobbs and others fail to make a careful distinction between conversational moves and deeper coherence relations, still others ignore the role of discourse moves entirely. Alterman (1985), for example, develops a taxonomy of concept coherence terms with which his system creates a complete representation of a narrative text without recourse to textual moves or moves. The obvious problem with this approach, in my opinion, is that without the structural clues provided by a discourse or text (such as topic and focus) it is impossible to adequately recover the interpretation of pronouns and deictic terms. For

example, in the partial text mentioned in section 1 (cf. (18)), *he* is bound by the NP mentioned in the previous sentence, *the peasant*. But it is not the underlying coherence relation that licenses this as much as the structural positioning of the antecedent relative to the pronoun.

Determining such structural environments for discourse anaphora has been the concerns of researchers such as Sidner, Grosz, Webber, and Reichman. One such licensing context is the *domain of focus*, which accounts for the anaphoric behavior of the pronoun discussed in the previous paragraph. These theories suffer, however, from the lack of any coherent representation of the deeper semantic relations between the discourse entities.

As discussed above, Reichman proposes a theory of discourse structure based on conversational moves. Clue words act to signal when a shift in context is being made. This model takes a surface representation (call it SS) and maps it into a discourse representation (DR) using these clue words as triggers for interpretation. Thus, an utterance such as (20b) is construed as a *support* for (20a).

(20) a. I don't like John, (b) because he's rich.

Let the interpretation of (20a) be represented by P, and (20b) by Q. The derived DR for this pair is then,

(21) P *because* Q → supports(Q,P)

Interestingly, however, there is another interpretation of (20) with the because connective (operator) inside the scope of the negative in (20a). The reading here can be paraphrased as, "It is not

the case that (P because of Q), but (P because of Q')." The function of *because* under this reading is not direct support, but rather to trigger an entirely different set of presuppositions. Namely, the fact that there is some other support to P that is not explicitly

mentioned, and that Q does *not* support P.

This points to the problem of what to take as the input to discourse analysis. Reichman assumes that surface structure is the natural choice, as do most structural analysts. This example, however, seems to indicate that Logical Form (LF) may have a feeding role into Discourse Representation. Any presuppositions or discourse moves associated with the second interpretation would have to be derived from the LF, where the appropriate scope assignments are represented (cf. (22)).

(22) [P *because* Q] → supports(Q´,P)

Although this is an isolated example, I think it is important to study such interactions in order to establish the feeding relations between the various interpretation levels.

Another criticism that can be leveled at Reichman concerns her misunderstanding of the Toronto school´s (Allen, Cohen, Perrault) meaning of "understanding." She points out that one mus t distinguish between a person´s *intention for an utterance* and the *communicative effect* of the utterance in context: "[While] a speaker´s intent may well be reflected by a communication, grasping that intent cannot be a necessary precondition for understanding."(Reichman (1984)). The confusion here is this: Reichman states that a hearer´s interpretation is dependent on the communicative effect of the utterance in context, and this may or may not be identical to the speaker´s intent. I agree with this, but I would not call this *understanding* the speaker. This is in fact the basis for misunderstanding in a communicative act. In order to fully understand the speaker, it is not a sufficient condition, but at least a necessary condition to recover the intent.

Finally the question arises as to where the model theoreticians fit into the discussion above. First, it is obvious that the major concerns are different for these researchers. Although questions of anaphora and reference are dealt with, Kamp's theory doesn't address the problems of inferencing or goal recognition and planning. Nor does he look at the structure or semantics of meta-sentential text and ask questions pertaining to coherence. Yet these are not his immediate interest. Heim addresses many topics related to Discourse Analysis as well, the emphasis being on the presuppositions from utterances, and the proper characterization of the *common ground*, the mutual belief space. Although this work highlights the importance of LF for later interpretation strategies, her concerns do not extend to the deep coherence relations addressed by Hobbs and others.

3.0 Levels of Discourse Analysis

In this section I would like to outline a model for discourse analysis based on fairly strict levels of interpretation and establish what the relationships are among the different components. In our discussion we will address the following questions:

1. What are the levels of analysis for Discourse Analysis?
2. What is the unit of analysis for Discourse Analysis?
3. How does Discourse Representation (DR) affect interpretation?
4. If DR is not the final semantic interpretation, then what is?

Although this model is obviously incomplete in the form outlined below, we claim to offer a new perspective which can contribute to the solution of some long-standing problems. We should also note that this is a proposal for a process-oriented model rather than a competence model (but I will not discuss this distinction here).

Let us begin by separating the structural or syntactic aspects of a discourse from the coherence relations, which we will call the "deeper semantics". First, it should be clear that the conversational moves discussed above in Section 1.1 are structural descriptions for the constituency of the discourse itself.

We will view a conversational move, following Carlson (1983), as involving the following parameters.

1. The author of the move.
2. The addressee(s) of the move.
3. The audience of the move.
4. The sentence of the move.

5. The game rule(s) which justify the move.

6. The premises of the move.

7. The dialogue(s) the move is in.

Perhaps most relevant to our discussion is the structure admissability which point (5) addresses. That is, a move is justified in the context of a larger structural unit, referred to as a game in Carlson's framework. We will return to this point later in our discussion of discourse syntax.

Also of a structural nature are the "domain" notions, such as focus and topic, which have meaning (for interpretation purposes) only within a context, i.e. a discourse. Constraints on the interpretation of anaphora and deixis are definable in terms of these notions.

Similarly, textual "directives", such as "elaboration', are syntactic rather than semantic in their function, since an elaboration of an expression may denote any number of semantic connections, from causation, non-causal explanation, to simple description. Thus, a textual directive (or cohesion relation) establishes a certain "inferential" connectedness without fully specifying what it is (cf. the comparison with coherence relations below).

We thus arrive at the following possible structural relations in a discourse:

1. A conversational move (CM); e.g. support, interrupt, challenge, etc.

2. A term that acts to delimit the evaluation of a discourse object,

   e.g. topic, focus, theme, rheme.

3. a cohesion relation, e.g. elaboration.

While it is impossible to characterize all discourses in terms of a set of common *structural* properties, there may be semantic similarities that all dialogue situations have (Cf. Carlson (1983) for such a view). Yet there are some text situations that lend themselves to a fairly straightforward analysis. These are the simple *monologue* structures, discourses involving one participant.

We can characterize the complexity of a discourse by the possible turns available at any stage in the dialogue. Single participant speaking situations, then, will have fewer turns available at any state than those with two, and so on. The simplest structure in this view will then be a *directed monologue*, where the goal of the speaker is brought about *by the manner in which the discourse is structured*.[11]

To say that directed monologues is the simplest discourse type is not to say that they lack complexity. Within this family of discourses we can distinguish several basic types, some still simpler than others:

Directed Monologue Types

1. Enumeration.
2. Elaboration.
3. Definition.
4. Description.
5. Proof-form.
6. Narrative.

---

[11] Other types of text and discourse will also meet this criterion, of course. For example, rhetorical argumentation, dialectic discussion, and other dialogues, achieve the goal of the participant by the structure of the discourse itelf. We do not have the space to discuss these here, however.

As an example of an enumeration, consider both texts below.

The reasons we should hire John are as follows: A, B, C, ...

There are several reasons for hiring John. First A, secondly B, ...

An elaboration monologue is a textual directive of "elaborate" for a larger text. For example:

(a) John can open Bill's safe.

(b) He has the combination,

(c) which he got from Mary.

There are actually two types of elaboration in this example. The relationship between (a) and (b) is an *explanatory elaboration* while that between (b) and (c) is a *descriptive elaboration*.[12]

Given the relative simplicity of directed monologues, we will suggest that there are useful structural generalizations that can be made about their form; namely, that a directed monologue is defined structurally as a text where one proposition acts as *head*, H, and at least one which acts as its *complement*, COMP. [13] Any other material in such a monologue can be analyzed as *adjunct* text. We say that the text is a projection of its head. Thus, a directed monologue, ***M***, has the following minimal structure.

---

[12] In a sense, however, they are both explanatory, since the latter explains *how* John has the combination. The nature of explanation, however, is a rich and complex topic in its own right, and well beyond the scope of our rather suggestive discussion here.

[13] We borrow these structural notions from linguistic theory. Cf. Chomsky (1981) for further explanation.

$M \rightarrow$ {...,H, COMP, ...}

The specific type of text will specify further syntactic properties, for example, the position of the head, and the number of complements, etc. To make this clearer, consider the text structure of an enumeration.

$M_{enum} \rightarrow$ Head COMP

COMP $\rightarrow p_1\ p_2 \ldots p_n$

The only structural commitment being made here is that the listing acts as a unit, independent of the head, or theme. This approach differs, then, from "systemic" classifications of text structure, in that we attribute to the text only a minimal structure, absent of any powerful functional labels.[14]

Moving on to discourses involving two participants we quickly see the limitations of our syntactic model. Such texts are simply too rich to lend themselves to such linear and single goal grammars. We will discuss the nature of more complex discourse in a later work (Pustejovsky (in preparation)). In the next section, however, we will idealize the data in a two-participant text, and attempt a generalization along lines similar to those outlined above.

We now consider the more interpretive aspects of discourse structure. The coherence relations we discussed earlier in section 1.2. are less structural in nature, although sometime they are related to specific structural realizations. Relations such as enablement, causation in general, or explanation are not uniquely or deterministically inferrable from the linguistic

[14] Cf. van Dijk (1980) for text classification approaches. Also, Mann (1984) and Mann and Thompson (1983) for a systemic analysis of text structure, and a very nice survey of some of the approaches taken to this problem.

or discourse structure alone. The structure of a dialogue can be characterized independently of coherence relations, but not of the cohesion relations and moves.

The major notion contributing to the semantics of an utterance in a given context is the intention of the speaker in performing that particular act. We will term this, somewhat casually, the "speaker's goal". This might be compared to Grosz and Sidner's Discourse Purpose, and we will discuss this similarity later in the paper.

Let us now attempt to organize these various contributing factors into a model for discourse analysis (DA). In the previous section we suggested that perhaps Logical Form (LF) is the appropriate input for discourse analysis rather than the surface structure (SS) itself. We will continue with that assumption here.

We will assume that any adequate model of discourse analysis should represent the distinctions between the structural properties and the semantic properties of the discourse. We will claim that the former should be viewed as comprising a level of Discourse Representation (DR) distinct from the purely syntactic or semantic interpretation of the utterance. Let us then propose the following hypothesis as the first link in the model:

(23) LF → DR

That is, the Logical Form of an utterance is seen as feeding Discourse Representation somehow.

Establishing such a model, however, is meaningless without examining what the unit of analysis for discourse analysis is. We will assume that the utterance, as defined by linguists, is the unit for analysis. One utterance may have several communicative effects, however, in terms of conversational moves and the speech acts conveyed. If DR is the level at which moves and directives are represented in our model, then the mapping from LF to DR is not one-to-one, but rather one-to-many. For example, any non-restrictive

relative clause can be thought of as (at least) an elaboration or further development of the NP it modifies. Yet for purposes of intra-sentential anaphora and binding, we must treat it as one sentence.[15] Similarly, adjunct clauses containing temporal adverbials and other connectives may very often signal a conversational move on the part of the speaker, and hence will map to a separate sub-representation.

In order to capture this mapping let us say that one of the primitives at DR is the *clause*, i.e. a simple proposition. The syntax of DR establishes the connectedness of these clauses in terms of the moves taken by the speaker (or inherent in the text). We express this as follows, where CF is the abbreviation for Clausal Form:

(24) $LF \rightarrow \{_{DR}CF_i\}$

The CF for the sentence "John loves Mary", for example, would be the standard logical representation "TNS(loves(j,m))", just as the NP "every woman" would have a representation $\lambda P(x)[woman(x) \rightarrow P(x)]$. We will not argue for a particular Logical Form, however, as this is not our major concern in this paper (but see Kamp (1981) and references therein for discussion of logical form for discourse). Regardless of what logical formalism is assumed as input to DR, it is important to stress that DR contains structural information that is beyond the scope of any general, context-independent linguistic formalism. The DR does not lose any information provided by the structural properties of LF.

We now define the structure of DR more completely. A Discourse Representation, DR, is the level of representation of the utterance derived from the logico-syntactic form, LF, which represents the cohesion relationships between clauses, the domain of topic and focus, and the moves associated with the utterance. The cohesion relations (the textual

[15] Reinhart (1983) addresses some of the problems of anaphora between main clause constituents and adjunct phrases.

directives) relate clausal representations, and these are then bound to a particular move. A DR may be associated with one or more moves in the larger discourse structure, but there must be at least one move associated with it.

This gives us the following derived structure.

$$LF \rightarrow \{_{DR} [_{M_1} CF_i] \cdots [_{M_n} CF_j] \}$$

This level is the structure on which we interpret:

1. The bindings between discourse anaphors and deictic terms and their antecedents; that is, the domains of "topic' and "focus' mentioned above.
2. The relationship between moves in the context of higher order structures (i.e. games or discourse trees, cf. below). In other words, how these individual moves combine to make a story-level or narrative discourse.

From this structure we derive a level that I will call Intentional Form (IF), by:

1. Establishing the deep coherence relations between clausal forms; and
2. Recovering the speaker's goal associated with the annotated discourse representation.

$$LF \rightarrow \{_{DR} [_{M_1} CF_i] \cdots [_{M_n} CF_j] \} \rightarrow IF$$

Two clausal forms may be connected by one of the following deep coherence relations:

1. Causal
2. Spatial
3. Temporal
4. Definition

Causality can be thought of as a covering term to include *occasioning*, *enablement*, and stronger senses of causation. For now, let us think of causation as a operator that limits or prunes the possible state space following an event. Thus, where b is *temporally subsequent* to a, we determine the strength of a causing b by examining b relative to the rest of the state space generated by a.

If a textual directive associates two clausal forms that are part of different moves, then this is termed a *move-directive*. These are the clue words that signal a change in the discourse space.

To illustrate how the above levels combine to form a model for Discourse Analysis, let us look at a sample discourse and the representations associated with the utterances.

A. The economy of Houston, where most US oil is refined, is rapidly declining,

B. Because the price of oil is falling.

Assuming an uncontroversial logical representation as input to our analysis, the DRs for A and B are given as follows:

DR_A [$_{M}$ type:statement &

Ex(x)[economy(x) of(x,H) & decline(x) &

ELABORATE(H,λx(most-oil-refined(x)))]

DR_B [$_{M}$ type:support &

BECAUSE(*m*,ιy(oil-price(y) &

falling(y)))]

The nonrestrictive relative in sentence A is embedded in a cohesion relation with the head of the relative, "Houston". Since "because" relates propositions in different moves, it acts as

a move-directive, and is analyzed similarly to clue words in Reichman's approach.

The IF associated with each utterance will establish any coherence relations between clauses, and will recover the speaker's goal. Speaking to the first point, notice that the elaboration in A will translate to a definitional relation. This particular definition *qua* description will allow the causal connection expressed by the move-directive, "because", to follow with less nontextual inferencing. That is, the connection between Houston's economy and oil prices is facilitated by this definitional coherence.

As noted, Intentional Form will represent the goals and plans associated with the utterance as well. Still the most elusive aspect of this level is the representation of mutual belief, the "common ground." Speaking in terms of what is presupposed and inferred by a listener, we will distinguish between:

1. those clausal forms that are asserted;
2. those clauses presupposed by the lexical structure of an item;
3. those clauses presupposed on the basis of structural configuration; and
4. those clauses presupposed as a result of convention.

That is, presuppositions are triggered by different elements in different environments (Karttunen, 1973, 1974).

Now we ask, at what levels are the various presuppositions derived or computed? Lexical presuppositions, we claim, accompany the LF structure into DR; that is, they are already computed. Structural presuppositions, on the other hand, are computed from LF and feed into DR. Conventional implicatures will be read off of DR itself, making use of information associated with clue words and other "conventional implicature triggers", while the presuppositions associated with beliefs and common ground will be computed at IF. IF,

notice, feeds into itself, indicating that inferencing is spawned as a result of these conventional inferences. In the next section we will outline our current implementation of a discourse inference system and how it manifests the theory of discourse analysis outlined above.

4. CICERO: Inference Controlling for Discourse Analysis

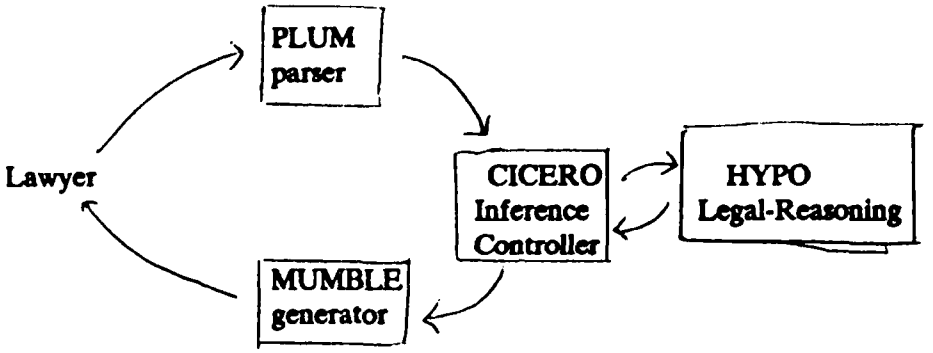
In this section I will like to describe the current capabilities of a system being designed at the University of Massachusetts. This project is part of a large natural language understanding system, COUNSELOR, currently under development in our department. I will first describe the scope of the research involved and how the various components interact. I will then give a detailed description of the discourse interpreter, CICERO, as well as the knowledge representation used by the system. At all times I hope to make it clear how this system's functioning relates to the model proposed in the previous section. For a more detailed view of the current implementation relating to design and control issues, see Pustejovsky et al (1986).

4.1 A Natural Language Interface for a Case-based Legal Reasoning System

COUNSELOR is the combined efforts of four separate projects to develop a case-based legal reasoning system with full natural language capabilities. The projected capabilities will allow a lawyer to interactively input the facts of a case, let the system analyze them, and propose the strongest arguments and counterarguments based on the given facts. The system that actually does the legal reasoning (HYPO) is essentially the intentional agent for the natural language front end, which consists of a parser, a generator, and a discourse interpreter.[16] The interaction of the systems is illustrated below.

---

[16] We will not be concerned with the actual reasoning capabilities of HYPO. Cf. Ashley and Rissland (1984) for details of the argumentation process involved in the system.



As an example of the text and discourse encountered by the system, consider the fragment below from an actual interactive session between an attorney, P, and the system, S.

P: I represent a client named HACKINC who wants to sue SWIPEINC and Leroy Soleil for misappropriating trade secrets in connection with software developed by my client. HACKINC markets the software, known as AUTOTELL, a program to automate some of a bank teller's functions, to the banking industry.

S: Did Soleil work for HACKINC?
P: Yes, he did.
S: Did he then later work for SWIPEINC?
P: Yes.
S: Was Soleil an employee on the AUTOTELL project?
P: Yes, in fact, he was a key employee.

This example illustrates two aspects of the understanding process: (1) fact and plan recognition (the opening paragraph); and (2) a question-answer interaction soliciting facts for the express purpose of formulating an argument.

4.2 Managing the Discourse

The discourse component of COUNSELOR is a program called CICERO, which can be viewed as essentially two subsystems. The first tracks and predicts the structure of a discourse based on conversational moves, interpreted through keywords and a discourse grammar. The other subsystem manages and controls the representation of the deeper semantic relations between discourse entities and predicates.

The basic components of the system are:

(1) A Knowledge Base defined in terms of *clustered objects*; and

(2) A best-first control strategy generating and recognizing the plans of the speaker and hearer, respectively.

A *cluster* is a particular way to represent both the objects in the world as well as mental objects such as plans and goals that operate over them. It is similar to most Frame Representation Languages with the associated inheritance properties (cf. Minsky (1975), Bobrow and Winograd (1977)).

The ontology consists of the following types:[17]

1. **objects**: frames representing real-world objects with associated role-goal pairs.
2. **states**: predicates over the objects.
3. **events**: functions from one state to another state.
4. **scripts**: prototypical event sequences.

Using examples from the dialogue above, let us examine what structure these clustered objects have, and what role they play in the interpretation of the discourse.

---

[17] In this implementation we assume a standard temporal logic, such as Allen's (1984) for interpreting and reasoning about the tense-based objects above.

Under the current implementation,[18] when the system begins to interpret the input from the user, the discourse tracking component of CICERO has already set the system-mode to expect a case-facts summary from either a layman or an attorney. That is, CICERO is expecting a particular kind of speech act; namely an *inform*. This top-down expectation is represented in the current discourse frame under the slot **:discourse-mode**, along with the contextual parameters, **:participants**, **:speaker-goal**, and **:hearer-goal**.

After the parse of the initial sentence, CICERO's task is to confirm any expectations it has concerning the speaker-goal, as well as to form a coherence representation of the semantic content of the proposition. The parse output for this sentence is a **legal-representation** frame, and passes this knowledge to CICERO that the speaker is an attorney. This in turn satisfies the precondition for the discourse-script shown in (25)—the coherence representation—and confirms the system's expectation for what the speaker's goal is; viz. to inform about a case.

The script illustrated in (25) clusters together the rhetorical moves associated with presenting information about a case for this particular situation. Each speech act of *inform* is represented as a separate action in the **:events** field, and this defines part of the larger textual structure of this preamble in the dialogue.

---

[18] The clusters including scripts have been implemented as flavors in Zetalisp on a Symbolics. For implementation details cf. Pustejovsky, Gallagher, and Bergler (1985).

```
(25)
(define-cluster accept-information-about-case script
    :participants ((hearer)
                   (speaker))
    :props ((lawsuit))
    :preconditions ( (speaker '(:type attorney)))
    :events ((t0 '((:optional)
                   (:code (establish-relationship-of-lawyer-to-party))))
             (t1 '((:head)
                   (:code (action-taken-by-the-plaintiff))))
             (t2 '((:head)
                   (:code (elaboration-of-case-perspective))))))
```

In addition to the instantiation of the discourse script above, the semantic representation of the "desire to sue", the **lawsuit** frame from the parser, is bound as the value of the **:conceptual-frame** for this discourse space, and in particular, it is of type misappropriation. The state of the discourse at this point (after the first sentence) is represented by the following discourse-frame and bindings:

```
(26)
(define-cluster legal-discourse-frame discourse-frame
    :participants ((hearer 'COUNSELOR)
                   (speaker '((:type attorney)
                              (:infer from legal-rep attorney))))
    :hearer-goal ()
    :speaker-goal ((inform 'legal-rep))
    :discourse-mode ((mode 'expect-inform))
    :discourse-script ((script 'accept-information-about-case script))
    :conceptual-frame ((lawsuit '(:type $misappropriation))) )
```

At this point the system operates in a top-down expectation-driven mode, triggered by the value for the **conceptual-frame** slot. That is, **$misappropriation** is itself a script, and the best-first control strategy used by CICERO chooses to instantiate the script as part of its inferencing about the coherence relations in the (upcoming) text.

```
(27)
(define-cluster $misappropriate script
   "legal concept"
   :participants
         ((plaintiff-corporation '((:type corporation)
                                          (:inherit thru parent lawsuit *)))
         (defendant-corporation '((:type corporation)
                                          (:inherit thru parent lawsuit *)))
                  )
   :props
         ((plaintiff-product '((:type product)
                                    (:infer from plaintiff-corporation product)))
          (defendant-product '((:type product)
                                    (:infer from defendant-corporation product)))
          (misappropriated-knowledge '((:type knowledge-about-a-product))))
   :preconditions ((t0 '((:code (produces plaintiff-corporation
                                                plaintiff-product))))
                  (t1 '((:code '(used-in plaintiff-product
                                          misappropriated-knowledge)))))
   :events ((t2 '((:code $illegitimate-access-to-knowledge)))
            (t3 '((:code (equal misappropriated-knowledge
                                 (get-value defendant-product :knowledge-used))
                                                                        )))
            (t4 '((:code $competitive-advantage))))
   )
```

This representation provides us with the logical arguments to a relation (the entailments), as well as a large set of presuppositions that will direct the inferencing—to establish the deep coherence— in later processing.

Notice that the discourse frame in (27) keeps a dual representation of the information streaming in from the parser. For structural bookkeeping purposes, the **$misappropriate** frame is bound to **action-taken-by-the-plaintiff**, in that it satisfies a particular structural property of such preamble paragraphs. For deeper semantic coherence, however, the same frame is bound to :type of a lawsuit, and carries the complex of information shown above in (27).

There are two interesting aspects to the representation shown in (27):

1. Any inferences possible due to the presupposition-set of an utterance are computed by CICERO rather than the expert system.

2. The exact same representation is used for understanding text as for generating text.

5.0 Conclusion

I have sketched in this paper a very rough model of discourse analysis based on a level hypothesis, wherein the conflating factors of discourse interpretation have been teased apart. In the previous section I attempted to demonstrate a working system, CICERO, which is "aware" of these levels at the stages of analysis outlined above. The system, howver, is still incomplete at this point, in that it fails to adequately simulate and model the speaker's belief space. Furthermore, the role of goal recognition as recovering the speaker's intention was minimal, due to the nature of the interaction in the domain. These topics are being addressed currently in our ongoing research.

Acknowledgements

I would like to thank Sergei Nirenburg, Wendy Lehnert, Kevin Gallagher, Sabine Bergler, John Brolio, Penni Sibun, and Dave McDonald for fruitful discussion on this topic. This work was supported in part by a grant from the Defense Advanced Research Planning Agency contract no. N00014-85-K-0017.

REFERENCES

Allen, J. (1984) "Towards a General Theory of Action and Time", Artificial Intelligence, 23.2.

Allen, J. and C.R. Perrault (1980) "Analyzing Intention in Utterances", Artificial Intelligence 15.3.

Ashley, K. and E. Rissland (1984) "Toward Modelling Legal Argument".

Austin, J.L. (1962) *How to do things with Words*. Cambridge, MA. Harvard University Press.

Bach, E. (1985) "The Algebra of Events". ms. (to appear in Lingusitics and Philosophy).

Bach, K. and R. Harnish (1982) *Linguistic Communication and Speech Acts*. MIT Press. Cambridge, MA.

Behagel, O. (1934) *Deutsche Grammatik*, Tubingen.

Barwise, J. and Perry, J. (1983) *Situations and Attitudes*, MIT Press.

Carbonell, J., (1979) "Computer Models of Human Personality Traits", Proceedings of AAAI-83. Washington, DC.

Carlson, L. (1983) *Dialogue Games*, Reidel, Holland.

Chomsky, N. (1981) *Lectures on Government and Binding*, Foris. Holland.

Cohen, P. and C.R. Perrault, (1979) "Elements of a Plan-Based Theory of Speech Acts", Cognitive Science 3.3. Ablex Publishing Corp.

Fillmore, C. (1971) "Verbs of Judging". in Fillmore and Langendoen

(eds), *Studies in Linguistic Semantics*. New York, Holt, Rinehart, and Winston.

Grice, H.P. (1968) "Utterer's Meaning, Sentence-meaning, and Word-meaning." Foundations of Language 4, 225-242.

Grice, H.P. (1969) "Utterer's Meaning and Intentions." Philosophical Review, 78, 147-177.

Grice, H.P. (1971) "Meaning", in Steinberg and Jacobovits (eds.) *Semantics: An Interdisciplinary Reader in Philosophy*.

Grice, H.P (1975) "Logic and Conversation". In Cole and Morgan (eds) *Syntax and Semantics*, vol 3.

Grosz, B. (1978) "Focusing in Dialogue", ni *Theoretical Issues in Natural Language Processing-2*, The Association for Computational Linguistics, University of Illinois at Urban-Champaign, July, 1978.

Grosz, B., (1981) "Focusing and Description in Natural Langue Dialogues", in Joshi, Webber, and Sag (eds), *Elements of Discourse Understanding*, Cambridge University Press.

Hajicova, E. (1983) "Topic and Focus", *Theoretical Linguistics*, 10 (2/3), 1983.

Heim, I. (1982) *The Semantics of Definite and Indefinite Noun Phrases*, Unpublished Ph.D. Dissertation, UMASS.

Hintikka, J. (1971) "Semantics for Propositional Attitudes".

Hobbs, J. (1979) "Coherence and Coreference", Cognitive Science 3.1

Hobbs, J. (1982) "Towards an Understanding of Coherence in Discourse",

in Lehnert and Ringle (eds.), *Strategies for Natural Language Processing*.

Karttunen, L. (1973) "Presuppositions of Compound Sentences", Linguistic Inquiry, 4 169-93.

Karttunen, L. (1974) "Presuppositions and Linguistic Context". Theoretical Linguistics, 1, 3-44.

Karttunen, L. (1976) "Discourse Referents", in J. McCawley (ed.), *Syntax and Semantics* 7, New York, Academic Press.

Kamp, H. (1981) "A Theory of Truth and Semantic Representation", in Groenendijk, Janssen, and Stokhoff (eds.) *Formal Methods in the Study of Language*.

Kaplan, D. (1977) "Demonstrative: An Essay on the Semantics, Logic, and Metaphysics and Epistemology of Demonstratives and other Indexicals", Draft 2., ms. UCLA.

Lehnert, W. (1978) *The Process of Question Answering*, Lawrence Erlbaum Ass. Hillsdale, NJ.

Lehnert, W. and M. Ringle (1982) *Strategies for Natural Language Processing* (eds.) Lawrence Erlbaum Ass. Hillsdale, NJ.

Litman, D. and J. Allen (1984) "A Plan Recognition Model for Clarification Subdialogues", Proceedings of COLING-1984.

Mann, W. (1984) "Discourse Structures for Text Generation". ISI Research Report 84-127.

Mann, W. and S. Thompson (1983) "Relational Propositions in Discourses". ISI Research Report 83-115.

Pustejovsky, J. (in preparation) "Dialogue Games and Discourse Grammars".

Pustejovsky, J. S. Bergler, and P. Sibun (1986) "On the Modularity of Discourse Analysis in Natural Language Understanding Systems" (submitted to AAAI-86).

Pustejovsky, J., K.Q. Gallagher and S. Bergler (1985) "Clustered Objects as Knowledge Representation for Natural Language". ms, UMASS.

Reinhart, T. (1983) *Anaphora and Semantic Interpretation*, Chicago. University of Chicago Press.

Rooth, M., (1985) *Associating with Focus*, dissertation, UMASS.

Schank, R. and Abelson, R. (1977) *Scripts, Plans, Goals, and Understanding*, Lawrence Erlbaum Associates.

Searle, J. (1969) *Speech Acts*. Cambridge, England. Cambridge University Press.

Stalnaker, R. (1979) "Assertion", in J. McCawley (ed.), *Syntax and Semantics 7*, New York, Academic Press.

van Dijk, T. "The Semantics and Pragmatics of Functional Coherence in Discourse", *Versus*, 26. 1980.

Webber, B. (1978) *A Formal Approach to Discourse Anaphora*, Ph.D. Dissertation, BBN Report No. 3761.

Wilensky, R. (1982) "Points: A Theory of the Structure of Stories in Memory", in Lehnert and Ringle (eds.), *Strategies for Natural Language Processing*.

Wilks, Y. and J. Bien (1983) "Beliefs, Points of View, and Multiple

Environments", Cognitive Science 7.2.

END

1-87

DTIC